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FOUR STAGES IN THE ALTERATION OF THE VILLENEUVE URANINITE

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During the winter of 1927 Dr. W. F. Ferrier in the course of rearranging the old mineral collection of the Geological Survey, which has been packed away in boxes for many years, came across a fine specimen labelled "Uraninite with Gummite L 31 R 1 of Villeneuve, Ottawa Co., Que." This unquestionably is the uraninite referred to in *G. S. C. Annual Report* for 1886, p. 10T by G. Christian Hoffman, then chemist and mineralogist to the Survey, who in December 1886 reported the receipt of this specimen weighing nearly a pound and noted that it was the first "pitchblende" found in Canada. The Lake Superior "coracite," an altered uraninite had been found long before this, however,

The specimen still weighs over 370 grams after removing some material for analysis and it evidently is only a comparatively small part of an originally much larger mass, thus substantiating a tradition which has been handed down to the effect that during the time of Hoffman a mass of uraninite the size of a cannon ball and weighing about 50 pounds was found in the Villeneuve mine. From the form of the specimen and the arrangement of the altered material one can readily believe that the original mass was roughly spherical and quite possibly 5 or 6 inches in diameter.

This uraninite is of particular interest because it shows four well marked zones of varying materials due to progressive alteration. Zone A, the part which evidently was nearest the centre of the original mass, naturally is the least altered and has a Sp. Gr. = 9.144, H = 6, colour steely black, lustre more or less metallic, and uneven fracture. Zone B, representing the next stage of alteration, has a Sp. Gr. = 7.779, H = 4.5, colour pitch black, lustre nonmetallic, fracture conchoidal. Zone C is composed of a beautiful bright "flame-scarlet" (Ridgway)[1] coloured substance with a Sp. Gr. = 5.273, H = 3.5, waxy lustre, and brittle conchoidal fracture. It has an index greater than 1.75 and is mostly anisotropic but does not appear to be entirely homogeneous. Zone D, representing the extreme stage of alteration, comprises an irregular layer seldom more than 1 mm. thick which evidently was the outside of the original uraninite mass in contact with the rocky matrix. On its outer surface it bears partly embedded scales of altered muscovite. A certain amount of D penetrates into C along fractures, etc., but D is plainly a more advanced alteration than C. The material of D is physically much like that of C but slightly softer. H = 3+, Sp. Gr. not determined, colour buff yellow to apricot yellow (Ridgway), lustre waxy, brittle, with a conchoidal fracture. It is anisotropic with index less than 1.75.

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Although the Villeneuve uraninite, probably a part of this very mass, was analyzed by Hillebrand[2] it appeared to the writer that this specimen offered a unique opportunity to obtain valuable data as to the effect of alteration on the lead ratio of uraninite. Here we have a single mass showing the whole sequence of alteration products all in place in their relative order and conveniently arranged in zonal fashion in sufficient quantity to permit obtaining samples for examination. Quantities of A, B, and C sufficient for chemical analyses were readily obtainable without injuring the appearance of the specimen, but to secure enough of D it would have been necessary to sacrifice the whole outer layer, so no analysis of this substance was made.

The main chemical determinations were made on 2 gram portions in the case of A and B, and on a single 1 gram lot of C. The sample of C as prepared for analysis was estimated to contain perhaps 25 per cent of D which it was impracticable to attempt to remove, as too much of C would have been lost.

The analyses yielded the following results:

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[1] Color Standards and Nomenclature.

[2] *Am. J. Sc.*, **42**, 390, 1891. Dr. Hillebrand states in part—No. 111 is an analysis of uraninite from the Villeneuve Mica mines, township of Villeneuve, Ottawa Co., Quebec. To Mr. G. C. Hoffman of the Can. Geol. Survey, who first recognized and reported this occurrence, I am indebted for the material analyzed.

ANALYSES OF A SINGLE SPECIMEN OF VILLENEUVE URANINITE AT VARIOUS STAGES OF ALTERATION.

	A H.V.E.	W.F.H.	B H.V.E.	C H.V.E.	Water Free to 100 Per cent			
					A	W.F.H.	B	C
PbO	11.43	11.27	10.73	14.93	11.51	11.44	11.48	16.56
(Pb)	(10.61)	(10.46)	(9.96)	(13.85)				
UO_2	41.08	34.67	9.49	none				
UO_3	34.98	41.06	62.42	60.36				
(Total U)	(65.34)	(64.74)	(60.33)	(50.24)	65.80	65.71	64.57	55.73
(As U_3O_8)	(77.03)	(76.33)	(71.13)	(59.24)				
ThO_2	6.40	6.41	6.23	7.66	6.44	6.50	6.67	8.50
(Th)	(5.63)	(5.63)	(5.48)	(6.73)				
(Th = U equiv.)	(2.14)	(2.14)	(2.08)	(2.56)				
(Ce, La, Di)$_2O_3$	0.79	1.51	0.68	0.14	0.80	1.53	0.73	0.16
(Yt, Er)$_2O_3$	3.31	2.57	2.97	1.61	3.34	2.61	3.18	1.79
Fe_2O_3 Al_2O_3, etc.	0.18	0.10	0.13	0.14				
CaO	0.36	0.39	0.42	1.37	0.36	0.40	0.45	1.52
MgO	0.03	——	0.02	0.12				
SiO_2	0.21	0.19	0.34	3.81	0.21	0.19	0.36	4.22
H_2O	1.70	1.47	5.97	9.42				
Bi_2O_3	([a]) ?	0.09	?	?				
CO_2				Small amt. undet.				
	99.47		99.40	99.56				
Sp. Gr.	9.144		7.778	5.273				
H.	6		4.5	3.5				
Pb/O+0.38 Th.	0.157	0.156	0.160	0.262				

[a] The lead precipitates after being weighed were tested for bismuth and not the slightest trace could be detected. In the filtrate from the sulfate precipitation of the lead, H_2S precipitated a small amount of a substance approximately corresponding in weight to the Bi_2O_3 reported by Hillebrand. This appeared to consist in part of a trace of lead not precipitated as sulfate, along with some other substance or substances not definitely identified. On conversion to chromates practically the whole precipitate dissolved in fixed alkali, but there were some slight indications of the presence of a little insoluble bismuth chromate. The amount of original sample was not sufficient to permit attempting exact determination of the supposed bismuth.

The analyses throw considerable light on the changes which may take place accompanying alteration. It is evident that in the case of the Villeneuve uraninite the percentages of Pb, UO_3, Th, Ca, SiO_2, and H_2O increase with increasing alteration, while total U, UO_2 and rare earths decrease. It also appears that the ratio of cerium group earths to yttrium and erbium earths decreases as alteration progresses. The lead ratio fortunately increases only slightly so long as the mineral remains black due to an appreciable UO_2 content, but once the UO_2 is entirely oxidized uranium is lost much faster than lead and the lead ratio rises to a large and entirely misleading value. This observation appears to supply the answer to the question whether to include the decomposition products, which arises when analyzing altered uraninites for age determinations. It is evident that all red and yellow decomposition products should be excluded, and probably results nearer the truth would be obtained if the material was given a preliminary digestion with hydrochloric acid to remove the more soluble alteration products. Much the same results as these were obtained by the writer some years ago in connection with the Cardiff township uraninite.[3] In fact it is now apparent that the analyses of this mineral represented in Table II by Todd[4] and the writer[5] show more or less similar .effects amongst which the augmentation of the lead ratio with increasing alteration is notable. The percentage of UO_2 relative to UO_3 in any uraninite gives an accurate index of the degree to which the mineral has altered, so that it may be seen that Todd's specimen was the least altered, followed in order by the "Ellsworth Hard XL" and the "Ellsworth massive much altered." The results are not strictly comparable because these were three entirely different specimens and the writer has found that single crystals from the same occurrence may vary slightly in composition. However, even so, it is clear enough that alteration of the Cardiff uraninite is accompanied by an increase in the Pb and Th, and a decrease in the total U content with also a decrease in the total rare earths. The effect on the CaO content is not certain. Further evidence of the effect of alteration in causing higher lead ratio is

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[3] *G. S. C. Sum. Rept.* **1923**, Part CI, p. 20 CI.

[4] T. L. Walker, *Contributions to Canadian Mineralogy*, **1924**, University of Toronto Studies, No. 17.

[5] *Loc. cit.*

TABLE II

ANALYSES OF URANINITES FROM ARENDAL, NORWAY, BY W. F. HILLEBRAND AND FROM CARDIFF TP., HALIBURTON COUNTY, ONTARIO, BY TODD AND BY ELLSWORTH.

	TODD Cardiff Hard XL	ELLSWORTH Cardiff Hard XL	ELLSWORTH Cardiff, massive, much altered	HILLEBRAND Arendal less altered	HILLEBRAND Arendal much altered
PbO	10.40	10.95	11.05	10.95	10.54
(Pb)	(9.65)	(10.19)	(10.25)	(10.16)	(9.78)
UO_2	45.18	39.10	13.55	44.18	24.18
UO_3	24.90	32.40	52.04	26.80	41.71
(Total U)	(60.56)	(61.44)	(55.26)	(61.27)	(56.05)
(As U_3O_8)		(72.44)	(65.15)		
ThO_2	11.40	10.60	13.56	3.48	3.00*
(Th)	(10.02)	(9.32)	(11.92)	(3.06)	(2.64)
(Th=U equiv.)	(3.81)	(3.54)	(4.53)	(1.16)	(1.00)
$(Ce, La, Di)_2O_3$	1.82	1.88	1.26	0.67	0.67*
$(Yt, Er)_2O_3$	2.74	2.14	1.87	9.05	9.76
Fe_2O_3	0.58	0.43	0.47	0.24	0.03
MnO	0.04	0.03	0.03		
Al_2O_3, etc.		0.09	0.11		
CaO	0.28	1.01	0.27	0.61	1.06
MgO	0.19	0.08	0.07	0.04	0.10
SiO_2	0.43	0.19	0.58	0.50	0.90
H_2O	0.61	0.65	1.60	undet.	1.23
He, etc.	0.35	0.31			
Insol.		0.15	0.67	1.19	1.10
CO_2 SO_4 P_2O_5			1.29		
		100.01	98.42		
Sp. Gr.	9.082	9.062	7.178		
Pb/U+0.38 Th	0.150	0.157	0.171	0.163	0.171

* ThO_2 and Ce group not separated. The value for ThO_2 given is a close approximation obtained by subtracting figure for Ce group in XVIII from total ThO_2+Ce group in XVII. In view of some apparent irregularities which became noticeable when these tables were compiled, *i.e.*, the small amount of CaO in the Ellsworth altered sample, compared with the relatively large amount in the Ellsworth hard XL sample it was thought to be worth while to re-analyze these for Th, rare earths, and CaO, since, fortunately, enough of the original ground samples remained. This was done during 1927 and the new results, which however differ but inappreciably from the old, have been used here. It was found further, that the values for the Ce and Yt groups had been transposed in the published analyses of the "Ellsworth altered Cardiff" sample.

to be seen in the case of Hillebrand's[6] two analyses of the Arendal, Norway, uraninite (Table II). One sample as indicated by the greater UO_3 content was evidently much more altered than the other and yields a considerably higher lead ratio.

From the evidence of the examples cited it is seen that the lead ratios of greatly altered uraninites containing up to 15% UO_2 may need scaling down to the extent of 0.01 or more. The question then arises whether all uraninites which have a UO_2 content greater than would be produced by autoxidation[7] alone do not yield lead ratios which are slightly too high. The amount of UO_3 due to autoxidation alone would not exceed 15 or 20 per cent for the uraninites considered here, so that UO_3 in excess of this must be the result of normal external alteration. The amount of the normal external alteration thus calculated may afford a rough index of the reduction in the lead ratio necessary to give exact results. It may well be that uraninites containing 10 to 20% UO_3 in excess of that due to oxidation should have their lead ratios scaled down by 0.002 to 0.005 to represent more correctly the true values. Evidently only a very small, practically negligible, correction of this sort is necessary for well preserved specimens but when dealing with considerably altered uraninites it might well be taken into account.

It is interesting to note that the effect of alteration on uraninite as just cited is exactly the opposite of the effect on complex titano-tantalo-columbates, which appear to lose lead to a greater degree than uranium.

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[6] *U. S. Geol. Survey, Bulletin* **78,** 1891, p. 67.

[7] H. V. Ellsworth, Radioactive Minerals as Geological Age Indicators. This Journ., Feb. **1925,** pp. 137, 144.

REPLACEMENT OF WOLFRAMITE BY SCHEELITE WITH OBSERVATIONS ON THE FLUORESCENCE OF CERTAIN TUNGSTEN MINERALS

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In September 1929, while on a rather hurried visit to the tin mines and china clay deposits of Cornwall, England, Captain M. T. Taylor of the East Pool Mine near Camborne, gave the writer a specimen that was very interesting and somewhat unusual. It came from a characteristic "lode fissure or crush conglomerate" at a depth of probably over 1500 feet. Of the twenty-two minerals listed by Ferguson and Bateman in "Geologic Features of Tin Deposits"[1] as occurring in Cornish mines, the specimen contains eight and, in addition, a ninth which they do not mention, namely, pyrrhotite. Nor does MacAlister in his "Geologic Aspects of the Lodes of Cornwall"[2] mention the occurrence of this mineral. It was thought at first that the pyrrhotite might possibly be stannite which although a very rare mineral, seems to be more common in Cornwall than pyrrhotite. However, the mineral is quite strongly magnetic, and specimens of stannite from Redruth, Cornwall; Zeahan, Tasmania; and Oruro, Bolivia; which were examined, were not at all magnetic. The mineral occurs in very small particles but possesses all the characteristics of pyrrhotite. The nine minerals identified, in the probable order of their importance are: quartz, wolframite, scheelite, arsenopyrite, pyrrhotite, chalcopyrite, fluorite, chlorite and cassiterite.

The wolframite is partially or wholly altered or replaced by pinkish scheelite, and the alteration seems to have taken place at right angles to the cleavage planes (010) and not parallel which would be easier, and this may be due to cross fractures in the vein along which calcareous solutions have circulated. In all places the wolframite is surrounded by the pinkish mineral. In some cases just a small particle of wolframite remains in the center of the grain, and in others the pink mineral, which is believed by the writer to be practically all scheelite, has completely replaced the wolframite.

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[1] Economic Geology, Vol. **7**, 1912, pp. 209–262.

[2] Economic Geology, Vol. **3**, 1908, pp. 363–380.

Figure 1 shows a large black mass of wolframite with pronounced clinopinacoidal cleavage (010). It also shows small seams of scheelite at right angles to the cleavage plane. Since the color of the scheelite in the specimen is pinkish, the color in the photograph is intermediate between that of the white quartz and the black wolframite. In the upper left hand corner is a mass of scheelite with three elongated plates of wolframite still unaltered.

Figure 2 is the reverse side of Figure 1, and in the lower left hand corner and upper center above the white quartz band, is to be seen especially well the black kernels of wolframite surrounded by grayish scheelite. The other six minerals on the specimen are not easily distinguishable in the photographs.

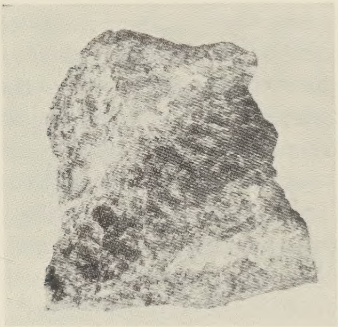

Fig. 1.

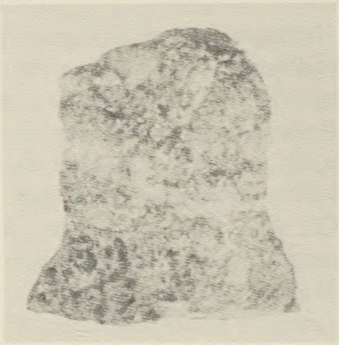

Fig. 2.

The writer loaned the specimen to Mr. Frank L. Hess, Chief Engineer, Rare Metals and Non-Metals Division, United States Bureau of Mines, Washington, D.C., who examined both a polished specimen and thin section. Mr. Hess says: "The polished specimen shows that replacement has taken place. The section shows that very little of the replacement has been made by scheelite. It follows an earlier mineral which was probably rhodonite but which is now greatly altered. As you will see in the section, there is a little fluorite, and fluorite, scheelite and quartz are later than the rhodonite, though possibly a little of the scheelite is earlier." The writer is very grateful to Mr. Hess for his interest and assistance. As Captain Taylor had stated to the author that the pink mineral was scheelite, while Mr. Hess thought that only a small part consisted of that mineral, the writer recalled that among the specimens which for years have been used to demonstrate the phenomena of fluorescence and phosphorescence under ultra-violet radiation, was one of scheelite from Atolia, California, which shows a bright light blue fluorescence, he therefore decided to test the Cornish specimen under the same conditions. The ultra-violet rays were produced by a high tension disruptive spark between iron terminals. The specimen in question showed the same beautiful bright blue fluorescence as the scheelite from Atolia, but with a darker blue color, so that the conclusion was drawn that practically all the pinkish mineral surrounding the wolframite was scheelite.

About this time, Mr. W. L. Lemcke, of Franklin, Pa., who had seen the abstract[3] of the paper given by the writer at the Washington meeting of the Mineralogical Society of America, December 27, 1929, noted the somewhat qualified statement: "The wolframite is partially or wholly altered or replaced by a pinkish mineral which seems to consist, at least in part, of scheelite." Mr. Lemcke wrote to inquire if the specimen had been subjected to ultra-violet rays because "sometime ago, Mr. Paul Walther kindly presented me with a specimen of milky-white translucent quartz containing black, bladed wolframite altering to pale yellow scheelite, from Carrock Fell, Cumberland, England. Under the iron arc, some of the scheelite exhibited a bright light blue fluorescence, and some a bright dark blue fluorescence. Moreover, a specimen of pale pink scheelite from Fairbanks, Alaska, kindly presented to me by Mr. Lewis Reamer, exhibited a bright beautiful blue fluorescence under the iron arc." Mr. Lemcke loaned his Carrock Fell specimen to the writer for investigation and suggested that if I had not already done so, it might be worth while to test all the minerals of the scheelite group at my disposal. He also called my attention to investigations by De Rohden on the discovery of rare earths in scheelites which is thought to cause the fluorescent phenomena, and which will be discussed later. The writer is under great obligation to Mr. Lemcke for his interest and help.

Altogether the writer investigated fourteen specimens of scheelite, one of which was artificial calcium tungstate; and twenty-five specimens of ferberite, reinite variety of ferberite, wolframite and huebnerite, four of which contained scheelite and are therefore listed in two places. These specimens with localities and various observations together with their behavior under ultra-violet radiation are listed below.

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[3] *American Mineralogist*, Vol. 15, No. 3, March, 1930, p. 120.

SCHEELITES

Specimen No.	Characteristics	Locality	Fluorescence
1	Massive, pink with wolframite, quartz, arsenopyrite, pyrrhotite, chalcopyrite, fluorite, chlorite and cassiterite.	East Pool Mine, Camborne, Cornwall, England.	Bright dark blue. Wolframite negative.
2	Granular white.	Atolia, California.	Bright light blue.
3	Crystal, yellow.	Caldbeck Fell, Cumberland, England.[4]	Bright light blue.
4	Crystal, yellow.	Kai, Japan.	Bright light blue.
5	Crystal, yellow, altering to reinite (Ferberite).	Kimbosan, Kai, Japan.	Bright light blue. Reinite negative.
6	Massive, yellow, with reinite.	Sannotake, Buzen, Japan.	Bright light blue. Reinite negative.
7	Granular, creamy, with stibnite.	Near Armidale, New South Wales, Australia.	Bright light blue.
8	Crystal, yellow, with iron tourmaline. Outside weathered cloudy, underside transparent yellow.	25 miles west of Cananea Sonora, Mexico.	Bright light blue on weathered surface, transparent yellow material absolutely none.
9	Aggregates of small crystals, greyish brown.	Zinnwald, Erzgebirge, Bohemia.	Crystals show none, but when powdered gave faint light blue.
10	Crystals, yellowish grey, with zinnwaldite and quartz.	Zinnwald, Erzgebirge, Bohemia.	Absolutely negative.

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[4] The locality of specimens 3, 12, and 13 are described by Paul Walther, *American Mineralogist,* vol. 5, No. 3, March 1920, pp. 54–57.

Specimen No.	Characteristics	Locality	Fluorescence
11	Massive, greenish grey, with molybdenite and hornblende.	Clifton District, Tooele County, Utah.	Negative.
12	Pale yellow altering from wolframite with quartz.	Carrock Fell, Cumberland, England.[4]	Bright light blue. Wolframite bright dark blue.
13	Pale yellow altering from wolframite with gruenlingite (Bi_4TeS_3) and quartz.	Carrock Fell, Cumberland, England.[4]	Bright light blue. Wolframite bright dark blue.
14	Artificial white $CaWO_4$.	Cleveland Wire Works, General Electric Co., Cleveland, Ohio.	Bright light blue.

WOLFRAMITES

For a classification and discussion of the various tungstates of iron and manganese, one should consult "Tungsten Minerals and Deposits" by Frank L. Hess.[5]

Specimen No.	Characteristics	Locality	Fluorescence
1	Ferberite.	Tirpersdorf, Saxony.	Negative.
2	Ferberite, var. Reinite.	Same as scheelite No. 5.	Negative.
3	Ferberite, var. Reinite.	Same as scheelite No. 6.	Negative.
4	Wolframite.	Same as scheelite No. 12.	Bright dark blue.
5	Wolframite.	Same as scheelite No. 13.	Bright dark blue.
6	Wolframite.	Same as scheelite No. 13.	Bright dark blue.

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[5] *Bulletin* **652,** *U. S. Geological Survey,* Washington, D. C., 1917.

Specimen No.	Characteristics	Locality	Fluorescence
7	Wolframite, with quartz.	Near Goldyke, Paradise Range, Nye Co., Nevada.	Very intense bright dark blue in cracks.
8	Wolframite.	Upper Lead, South Dakota.	Intense bright light blue.
9	Wolframite.	Upper Lead, South Dakota.	Less intense bright light blue.
10	Wolframite or dark huebnerite.	Lawrence Co., South Dakota.	In spots bright light blue.
11	Large crystal wolframite with zinnwaldite and quartz.	Zinnwald, Erzgebirge, Germany.	In spots weak light blue.
12	Large crystal wolframite.	Same as No. 11.	Faint, light blue, almost negative.
13	Crystal wolframite.	Same as No. 11.	Same as No. 12.
14	Crystal wolframite.	Same as No. 11.	Same as No. 12.
15	Crystal wolframite.	Altenberg, Erzgebirge, Germany.	Same as No. 12.
16	Wolframite with arsenopyrite, chalcopyrite, and quartz.	Cornwall, England.	Negative.
17	Same as No. 16.	Same as No. 16.	Same as No. 16.
18	Wolframite with quartz.	Borestown, New Brunswick, Canada.	Negative.
19	Wolframite or dark huebnerite.	Bolivia.	Very little.
20	Wolframite or dark huebernite. Fresh cleavage pieces.	Bolivia.	Negative.
21	Wolframite.	Llallagua, Bolivia.	Negative.
22	Huebnerite with quartz.	Minnesota Gulch, near Silverton, Col.	Negative.

Specimen No.	Characteristics	Locality	Fluorescence
23	Same as No. 22.	Same as No. 22.	Negative.
24	Huebnerite.	Near Deadwood, South Dakota.	Negative.
25	Huebnerite with quartz.	Redlicht District, Esmeralda Co., Nev.	Strong bright light blue.

An inspection of the results shows that fluorescence is the rule among the scheelites but that in the crystals from Zinnwald it is practically absent or very weak (Nos. 9, 10). The same was true with No. 11. On the other hand the phenomenon is the exception among the wolframite minerals, only eight out of twenty-five specimens showing any indication of color change. It is, however, to be noted that the specimens of wolframite from Zinnwald show the fluorescence better than the scheelites from the same locality. None of the specimens showed any phosphorescence after the source of the excitation was removed.

Since it seemed possible that the phenomena might be due to surface changes caused by alteration, such as oxidation to tungstite (WO_3), a specimen of tungstite on wolframite from Ponga, Oruro, Bolivia, was tested and both minerals gave absolutely no fluorescence. Mr. W. P. Sykes of the Research Laboratory of the Cleveland Wire Works of the General Electric Company kindly furnished the writer with a sample of artificial WO_3 and $CaWO_4$. The former gave no results while the latter showed the normal fluorescent color given by most scheelites. (See No. 14). Mr. Sykes stated that both artificial substances were pure. It, therefore, seems probable that all the eight wolframites which fluoresced were coated with a small amount of scheelite due to alteration or replacement similar to the specimen from the East Pool Mine, which was the original cause of this article, but in which the changes had gone farther, even to the complete alteration of the wolframite.

The writer had no specimens of cuproscheelite or cuprotungstite, powellite, or stolzite, which are the other members of the scheelite group, to investigate (wulfenite shows no color), and it is to be hoped that others who have these minerals will test them under ultra-violet rays. With this in view, the Department of Mineralogy at the University of Michigan was asked to investigate their specimens, and Professor Walter F. Hunt, to whom my thanks are due, wrote as follows: "This afternoon I made the tests with the iron arc. As we do not seem to have tungstite in the museum, I could not run the test on that mineral. I tested scheelite from California; Dragoon Mts., Arizona; Idaho; Derbyshire; Kai, Japan; Schwarzenberg; Schlaggenwald; and a number from Zinnwald. All showed various shades of blue with the exception of those from Schlaggenwald and Zinnwald. Here most of the specimens gave negative results with the exception of one massive white specimen which gave a beautiful blue fluorescence. Apparently those from Zinnwald behave differently, as a rule, with the exception of that single specimen, and it is barely possible that the label as to locality is not correct in that case. None of the wolframites were affected with the exception of a wolframite pseudomorph after scheelite from Monroe, Conn., and here no doubt the blue was due to some unreplaced scheelite." In general, the results obtained by Dr. Hunt conform to those obtained by the writer.

Mention has already been made of an article by C. De Rhoden, "Sur La Phosphorescence Cathodique des Scheelites et des Alumines"[6] He investigated seven scheelites under cathode rays and found them all to "phosphoresce," and that the colors of three of the seven were "persistant." I assume that all fluoresced under cathode rays and that three phosphoresced when the source of excitation was removed. He examined this "phosphorescent" (fluorescent?) light with a spectroscope and found bands, although not of the usual kind, indicating the presence of dysprosium and samarium in all seven scheelites. Terbium was found in five, europium in two, and praseodymium, neodymium, and erbium, in one specimen each. Three scheelites came from unknown localities, two from Marmolejo, Cordoba, Spain; one from Waipone, Otago, New Zealand, and one from Gangthal Salzburg, Austria. The writer had no specimens from any of De Rhoden's known localities, and is not sure that his phosphorescence under cathode rays is identical with the fluorescence under ultra-violet radiation, but it is very clear that De Rhoden believes that the phenomena observed by him on seven scheelites is due to the presence of the rare earths enumerated above. He further states that Cossa[7] observed in scheelites from Traversella, Italy; Jumilla, Spain; and Meymac, France, the absorption spectrum bands of didymium, cerium and lanthanum, and that Cossa made artificial scheelite containing didymium which showed the same bands as the natural occurring specimens.

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[6] *Annales de Chimie*, 9 serie, 3–4, **1915**, pp. 338–366.

CONCLUSIONS

The writer has described the alteration or replacement of wolframite by scheelite from the East Pool Mine, Camborne, Cornwall, England, and has found that most scheelites fluoresce under ultra-violet radiation, and that some wolframites and huebnerites show the same phenomenon. It is suggested that in the last mentioned minerals this is caused by a slight alteration to scheelite. No explanation can be given why the scheelites Nos. 9, 10, and 11 do not show fluorescence unless we accept the explanation of De Rhoden, and assume that they do not contain the rare earths. It should also be remembered, however, that the artificial scheelite, No. 14, said to be pure $CaWO_4$, fluoresces like most of the natural scheelites. The whole object of the latter part of this paper has been to record the results obtained and to stimulate further investigations on the subject and especially on the cause of the fluorescence of the various tungsten bearing minerals.

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[7] *C. R. Acad. Sc.*, Vol. **LXXXVII**, p. 377.

URANINITE FROM PLACER DE GUADALUPE, CHIHUAHUA.*

Roger C. Wells, *U. S. Geological Survey.*

Introduction

The interest attached to pitchblende as a source of radium has recently been intensified by the study of the problem of the genetic relationships existing between its constituent elements, and analyses of material from new localities are especially desirable. The principal point to be determined is the ratio of the lead to the uranium, which gives the age of the pitchblende, but other matters, such as the presence of thorium, rare earths, and isotopes of uranium, may have some additional importance.

As analyses are accumulated, the general idea that the older pitchblendes—in terms of geologic time—have higher ratios of lead to uranium seems to be substantiated. Some qualifications of this idea with reference to the containing rocks have been given by Fersman,[1] such as the possibilities that (1) pegmatites in the same intrusive may have different ages, (2) minerals in the same pegmatite may have slightly different ages, (3) uraninite may have acquired lead at its formation,[2] and (4) there may have been alterations and replacements.[3] Fersman cites a uraninite from Sinyaya Pala, Karelia, White Sea district, analyzed by Nenadkevich, having Pb/U = 0.296 and the atomic weight of the lead = 206.06; this is one of the oldest uraninites so far reported, if the theory can be applied without qualification.

The uraninite of which the analysis is reported in this paper has several interesting differences from most other uraninites. It occurs in a calcite vein and has a high specific gravity, a high UO_2 content, indicating relatively little alteration, and a lead-uranium ratio indicating that it is relatively young. It contains, however, between 5 and 6 per cent of rare earths.

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[1] E. A. Fersman, The age of uranium minerals of pegmatite veins. *Bull. Acad. Sci., U.S.S.R.*, **1926**, 775–80.

[2] This possibility is partly ruled out if the lead is shown by its atomic weight to be uranium lead.

[3] See also Hess and Wells, *Am. J. Sci.*, [5] **19**, 18–26, 1930.

OCCURRENCE OF THE MINERAL

The specimen was collected by Dr. W. F. Foshag, of the United States National Museum, to whom the writer is indebted for the following information as to its occurrence. It came from the Virgen mine, at Placer de Guadalupe, a small town about 72 miles east of the city of Chihuahua, Mexico. The nearest railroad station is San Sostenes, 6 miles away.

In this district the chief rock formations are limestone, shale, and sandstone of Mesozoic age. The rocks in the immediate vicinity of the mine have been determined by Böse[4] to be Upper Jurassic. Intruded into them are a few small porphyry dikes.

Pitchblende also occurs in another mine, the Puerta del Aire, about 2 miles from the Virgen mine. In the Virgen mine the pitchblende is found in a calcite vein about 2 feet thick that lies between a footwall of dark-purple porphyry and a hanging wall of black fissile shale. The calcite has been mined for gold, which occurs intimately associated with the pitchblende. Above the water level the pitchblende is leached out, and most of the cavities left are filled with reticulating wires of gold and show small quantities of uranophane and thin coatings of a dark-green undetermined uranium mineral. A little pyrite is scattered through the calcite.

The pitchblende ranges in size from small specks to nodular masses as large as walnuts. It has colored the calcite pink. The pitchblende is invariably accompanied by gold, although gold may be found without pitchblende.

The porphyry footwall is cut by numerous small veins of calcite, generally rich in gold, and is hydrothermally altered to sericite. The veins are later than the Jurassic sediments and later than the porphyry dikes. Intrusive masses similar to the one associated with these veins are found in many places in Mexico cutting an older andesite series, which is presumed to be of Middle Miocene age.

ANALYSIS

The material, already very clean, was hand picked and washed for a short time with dilute hydrochloric acid before drying and weighing. There was sufficient material for two analyses. For the first, 1.9985 grams was used; for the second, 2.0676 grams. The soluble silica found was less than 1 milligram and is not included in the weight taken.

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[4] Unpublished manuscript.

The methods of analysis used followed in a general way schemes which have been published elsewhere.[5] Some attention was paid to certain features suggested by Hillebrand[6] and followed by C. W. Davis.[7] The last two investigators converted the uranium to sulfate and added alcohol to the solution in dilute sulfuric acid. As they give no figures to show the results of this treatment it may be of interest to know the order of the correction found by the writer. In the second analysis the insoluble sulfates resulting from the treatment with alcohol were found to contain: rare earths 0.0007 gram; CaO 0.0021; and U_3O_8 0.0023.

Hillebrand and Davis further converted the uranium to nitrate and extracted it with ether, in which uranium nitrate is easily soluble. In this way the writer found 0.0020 gram of rare earths, of which 0.0004 was ThO_2, in the residue insoluble in ether.

The R_2O_3 hydroxides were separated from calcium by one precipitation. Thus the results for calcium were finally:

Main CaO	0.0037 gram
Insoluble in $(NH_4)_2CO_3$	.0029
Insoluble in alcohol	.0021
	0.0087

In the first analysis the uranium was purified by the cupferron method[8] and weighed as U_3O_8.

The water was calculated from the change in weight on ignition of the mineral—actually a gain, owing to the oxidation of UO_2 to U_3O_8. There was not enough material available for a direct determination of the water.

Until the atomic weight of the lead is determined the lead may be assumed to be uranium lead. The age of 36 million years for the uraninite would then place it in late Oligocene time according to Barrell's time scale. Thus the age of the veins as computed from the lead-uranium ratio is a little greater than the supposed age

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[5] R. C. Wells, Samarskite from Petaca, New Mexico. *Am. J. Sci.*, [5], **19,** 17, 1930.

[6] W. F. Hillebrand. *U. S. Geol. Survey, Bull.* **78,** 47, 1891.

[7] C. W. Davis. *Am. J. Sci.*, [5], **11,** 201, 1926.

[8] Holladay and Cunningham. *Am. Electrochem. Soc. Trans.*, **43,** 329, 1923.

RESULTS OF ANALYSES

	1	2	Mean	
UO_2	70.17	70.00	70.09	=80.67 U
UO_3	22.72	22.66	22.69	
ThO_2	0.05	0.34	0.20	= .18 Th
CeO_2	0.71	....	0.71	
La_2O_3, etc.	1.02	....	1.02	
Y_2O_3, etc.	3.20	3.62	3.41	
Fe_2O_3	0.13	0.06	0.10	
As_2O_3	0.06	....	0.06	
PbO	0.41	0.38	0.40	= 0.37 Pb
CaO	0.17	0.42	0.30	
TiO_2	0.06	....	0.06	
Al_2O_3 (?)	0.25	0.25	0.25	
H_2O	(0.41)	....	(0.41)	
	99.36		99.70	

Sp. Gr. = 10.63

$$\frac{Pb}{U}=\frac{0.37}{80.67+(0.38\times 0.18)}=0.0046$$

Age = 0.0046 × 7900 = 36 million years.

based on the geologic evidence, but considerably less than that of the Upper Jurassic rocks into which the porphyry dikes are intruded.

The specific gravity, 10.63, determined by the pycnometer, is the highest so far reported for uraninite. This gravity is presumably caused by the freshness and high UO_2 content of the mineral. Pure UO_2 is reported to have a density of 10.95, U_3O_8 7.31, and UO_3 powder 5.2, but the density of the mineral calculated from these figures would be below 10, from which it appears that the figure given for the density of UO_3 is too low or does not correspond to the compact structure of the mineral.

PEGMATITE MINERALS OF ONTARIO AND QUEBEC (Concluded)

Hugh S. Spence, *Mines Branch, Ottawa, Canada.*

(*Continued from page 451*).

Quartz

Massive, white quartz occurs in abundance in the pegmatites, in ledges, stringers and often in large segregated bodies. Often, quartz constitutes the principal mineral of a dyke, and if transport conditions permit, the dyke can sometimes be worked for quartz, with feldspar as a by-product. In the Buckingham district, Que., large tonnages of pegmatitic quartz are mined, or saved at feldspar mines, and shipped to the works of the Electric Reduction Company, at Buckingham.

Most of the quartz is cloudy and non-transparent. Occasionally, it is smoky, and sometimes milky. Clear, glassy quartz is not common, but is found at some of the mines in small amount. Pale, rose quartz occurs at the Villeneuve mine, Que., and in a dyke in Lyndoch township, Ont.: the colour is not, however, good enough to be suitable for ornamental purposes.

Freely crystallized quartz is not common, owing to the comparative rarity of vugs or cavities in the dykes, and when found, is generally cloudy and of poor quality. Small, distorted crystals of smoky quartz occur scattered through calcite at the McDonald mine, near Hybla, Ont.

In many of the pegmatites, a large proportion of the quartz present occurs in graphic granite intergrowth with the feldspar, and some dykes consist almost wholly of graphic granite. Others contain irregular masses of graphic granite, distributed through or around zones of segregated feldspar and quartz.

Samarskite

The occurrence of small amounts of massive samarskite at the old Maisonneuve mica mine, in Berthier county, Que., is mentioned by Obalski (17), (26), (56), (57) who also records (56) it from the Pied des Monts mica mine, in Charlevoix county, Que. It is stated (53) to have been observed in the beryl pegmatite in Lyndoch township, Ont. (See also calciosamarskite).

Sphalerite

A single occurrence of sphalerite in noteworthy amount in a pegmatite has been observed by the writer in Dill township, Sudbury district, Ont. Here, the sphalerite occurs in a small, vuggy, vertical shoot, or chimney-like vein, near one wall of the dyke. The mineral is black and massive, and is associated with muscovite, plates of which lie embedded in the sulphide. The occurrence is possibly related to the metalliferous veins of the Sudbury basin, the rim of which lies a short distance to the north.

THUCHOLITE

Thucholite is a remarkable, rare carbon mineral containing rare elements, and has been recorded from a few Canadian pegmatites. It was first noted about 35 years ago by Obalski (14), (51) in the Pied des Monts mica mine, near Murray Bay, Que., where it occurs in small amount with uraninite. Ellsworth has since described (13) an interesting occurrence of the mineral in a red pegmatite in Conger township, Parry Sound district, Ont., where it occurs associated with uraninite, samarskite, allanite and cyrtolite, and also an occurrence in a white dyke in Derry township, Que., where it is associated with allanite, uraninite, and cyrtolite (13). From this last locality, Ellsworth illustrates an interesting pseudomorph of thucholite after tourmaline.

The writer has lately noted an even more remarkable occurrence of thucholite in the Parry Sound district, where it is found with uraninite, cyrtolite, titanite and allanite. This occurrence will be described in a paper shortly to appear in this Journal.[1] The chief points of interest in connection with the deposit are the comparative abundance of the thucholite, and the fact that it occurs in cubic crystals, often of large size, and apparently pseudomorphous after uraninite; also, that a thick oil, as well as a substance resembling elaterite, which hardens on exposure to a pitch-like consistency, also occurs in the dyke.

Obalski termed the Murray Bay mineral simply "coal." Similar carbonaceous material from the crystalline rocks of Canada later usually was designated anthraxolite, a name first given to such a substance from Lake Superior and later applied, more specifically, to the hard, vein-like carbon of the Sudbury district, Ont. The term thucholite has been proposed by Ellsworth for the true pegmatitic carbon, the name being formed from the chemical symbols of some of the main constituents—thorium, uranium, carbon and water.

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[1] The article referred to will appear in the November issue of the Journal.

TITANITE

Titanite is not a common mineral in the pegmatites, but is sometimes present in small amount in the wall zones.

At the McDonald mine, near Hybla, Ont., which has yielded so many interesting rare-element minerals, brown titanite in crystals measuring sometimes several inches in length occurs associated with ellsworthite and cyrtolite in pink calcite, as well as in the feldspar of other parts of the dyke. Small masses, sometimes possessing obscure crystal outline, of a brown mineral that appears to be an intimate mixture of titanite and hatchettolite, also occur here. Titanite also occurs at the nearby Plunkett mine (23).

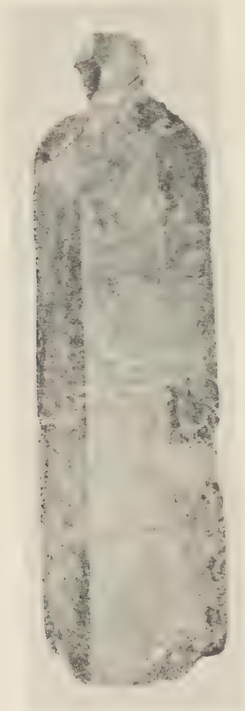

FIG. 2. Large, twinned crystal of titanite, with small, terminal individual in parallel growth, from lot 14, concession VII, township of Calvin, Nipissing district, Ontario. (½ Natural size).

In a dyke in Calvin township, near Mattawa, Ont., both fresh, brown and altered, greyish-green titanite occur adjacent to the wall. An interesting, twinned crystal from this dyke is illustrated in Fig. 2.

Enormous brown titanite crystals, associated with very large zircons, were formerly obtained (33) from the apatite-bearing, pyroxene-feldspar pegmatites of Sebastopol township, in Renfrew county, Ont., but these pegmatites do not come within the class of those dealt with in this paper. Similar large crystals, however, occur in a coarse granite in North Crosby township, near Westport, Ont.

Small titanite crystals occur in a white pegmatite cutting crystalline limestone in North Burgess township, Ont., associated with diopside, calcite, apatite and pyrite (35), and also in a similar dyke in Loughborough township, Ont. (4).

TODDITE

(See columbite)

TOURMALINE

The black schörl variety of tourmaline is one of the commonest accessory minerals in the pegmatites, and most dykes contain it in some amount. It occurs frequently in groups of radiating, acicular crystals penetrating feldspar or quartz, the groups often radiating outward from cracks or joints. It is sometimes found in large, well-formed prisms having the rounded triangular outline typical of the mineral, and then often exhibits rhombohedral terminations.

Good examples of large crystals, sometimes one inch or more across, are found at the Villeneuve mine, in Villeneuve township, Que., and at the Leduc mine, in Wakefield township, Que. At the former locality, tourmaline also often occurs embedded between the plates of muscovite crystals, and the mine has also yielded interesting pseudomorphs of muscovite, garnet and quartz after tourmaline. The Villeneuve tourmaline is often altered externally to muscovite, and in this mica there often occur small, nodular pellets of gummite. Very large tourmaline crystals are also associated with euxenite and monazite in a dyke in West Portland, Que.

The lepidolite-bearing dyke at the Leduc mine, in Wakefield township, Que., carries considerable green and lilac-red tourmaline, in addition to the black, but the mineral is cloudy, flawed and of poor quality. An attempt was once made to mine this pegmatite for gem tourmaline, but with disappointing results.

Large tourmaline crystals also occur in the beryl pegmatite in Lyndoch township, Ont. Large masses of rather loosely-intergrown tourmaline crystals, in the cavities of which sit splendent pyrite individuals, are found at the O'Brien mine, in Derry township, Que.

TREMOLITE

Massive, fibrous tremolite is sometimes found as a contact mineral in the wall zones of pegmatites cutting crystalline limestone, as in a dyke on Rock lake, in Storrington township, Ont.

URANINITE

Uraninite occurs somewhat sparingly in certain of the pegmatites, but it is to be included among the rarer minerals.

It has been found probably in greatest amount at the old Villeneuve mica mine, in Villeneuve township, Que., where it occurred usually in small pellets, but sometimes also in larger masses up to one pound in weight (20), (48). It was often associated with gummite of a brilliant scarlet-orange colour. It has also been noted in small amount in a similar dyke in the adjoining township of West Portland, and also at the Leduc mine, in Wakefield township.

Uraninite occurs (51) at the Pied des Monts mine, near Murray Bay, Que., associated with thucholite. It is also found in small cubic crystals in certain of the dykes in Buckingham township, Que., and at the Wallingford mine, in the adjoining township of Derry, where it is also associated with thucholite. (13).

In Ontario, it has been described by Ellsworth (13) from the township of Conger, Parry Sound district, where it occurs in cubic crystals up to one inch in diameter, associated with thucholite, samarskite and cyrtolite. It also occurs in some quantity, both in crystals and massive, in the remarkable thucholite-bearing pegmatite in Henvey township. Small amounts have also been found in dykes in Butt Township, in Nipissing district (19), (27). In the western part of the Province, there is an early record (49) of uraninite (coracite) near Mamainse, on the east shore of Lake Superior, but the location has been lost and nothing accurate is known about the occurrence.

The most important uraninite discovery in Canada to date is that in Cardiff township, near Wilberforce, where the mineral has recently been found to occur in considerable amount (24). This occurrence is associated with syenite pegmatite and is described under that class of dykes.

URANOPHANE

Small groups of minute, yellow, waxy crystals, that are probably uranophane, accompany the uraninite and thucholite of a dyke in Henvey township, Parry Sound district, Ont. The mineral is also recorded (58) from the Villeneuve mine, in Villeneuve township, Que.

URANOTHORITE

Ellsworth has described (8) a thorite, rich in uranium and calcium, from the McDonald mine near Hybla, Ont. The mineral occurs in square prisms, up to one-half inch across, embedded in feldspar or quartz. This is the only recorded occurrence of thorite in Canada.

XENOTIME

Stated (31), (59) to have been found years ago in small amount at a mica mine in Calvin township, near Mattawa, Ont.

ZIRCON (VARIETY, CYRTOLITE)

The cyrtolite variety of zircon is a fairly common mineral in the pegmatities, particularly in those of the Hybla area, Ont., and in the Parry Sound district, Ont.

At the McDonald mine, near Hybla, cyrtolite is quite abundant throughout the dyke. It occurs as small individual crystals, or groups of crystals, and also in masses up to several pounds in weight, embedded in feldspar or quartz. It also occurs at the nearby Woodcox mine. (5).

In the Parry Sound district, cyrtolite is found in Conger (13), Henvey and other townships, where it is usually associated with rare-element minerals. Cyrtolite, indeed, seems to be a common associate of such minerals in the granite pegmatites of eastern Ontario.

Small amounts of cyrtolite accompany the euxenite in South Sherbrooke township, Ont., and it is also found in some quantity in the beryl pegmatite in Lyndoch (10).

In Quebec, no important occurrences are recorded. Small cyrtolite crystals, however, occur sparingly in the Villeneuve dyke, in Villeneuve township, and also in West Portland. Zircon is also recorded (53) from the Pied des Monts mica mine, near Murray Bay, Que.

Normal zircon does not occur, or at best, is extremely rare, in the granite pegmatites. Very fine zircons, however, were formerly found in the apatite-bearing, pyroxene-feldspar dykes of Sebastopol and Brudenell, in Renfrew county, Ont., where large crystals, measuring 12×4 inches, and weighing as much as 15 pounds, were obtained (33). Small crystals also occur in the syenite pegmatite of Cardiff township.

An interesting phenomenon in connection with the occurrence of cyrtolite in the dykes is the pronounced shattering effect that the mineral has exerted on the quartz and feldspar in which it is embedded. Quite small masses, and even single crystals, of cyrtolite often produce radial shattering to a remarkable degree, and the writer has observed an instance in the wall of the McDonald mine, near Hybla, Ont., where a small mass of cyrtolite, less than one inch across, had caused radial cracks over four feet long in the surrounding quartz. This phenomenon is not confined to cyrtolite alone, but seems to be common to a number of the rare-element minerals. It has been remarked by Ellsworth (19), and has been studied by Walker and Parsons in a special paper (5).

Cyrtolite is an interesting mineral on account of it having yielded the recently-discovered element hafnium. The Canadian cyrtolites seem generally lower in hafnium than those from Bedford, N.Y. (5.5 per cent HfO_2), and Rockport, Mass. (9.0 per cent HfO_2). Professor von Hevesy, who has kindly determined the hafnium content of the Henvey and Hybla cyrtolites, reports (private communication to the author) that the former yielded 2.14 per cent HfO_2, and the latter, 2.36 per cent.

B. SYENITE PEGMATITES

Description

The pegmatites included here comprise a class of dykes apparently having a restricted, regional distribution in the Bancroft-Wilberforce district, counties of Hastings and Haliburton, Ont. They are related either to the nepheline syenites of the region or to the marginal syenitic facies of large granite batholiths, several of which occur in the area. The geology of the district was studied and described by Adams and Barlow about 25 years ago (36), since when there has been little further published.

Mining operations upon these pegmatites have been confined to a few shallow openings made for mica, in Faraday township, and for fluorite and radioactive minerals, in Cardiff township; hence, little opportunity has been afforded to study the dykes. The minerals here described were found at some pits made for dark mica on lot 32 in the fifteenth concession of Faraday township; at fluorite workings on lots 8 and 9 in concession 21 of the township of Cardiff; at openings made in 1929 for uraninite on lots 4 and 5 in concession 21 of the same township; and on lot 10 in concession 12 of Cardiff.

The dykes, as far as observed, consist of very irregular bodies of medium-grained syenite, made up principally of reddish-buff plagioclase and pyroxene, with accessory fluorite, zircon and garnet; nephelite is present locally. In these dykes occur miarolitic cavities, sometimes of large size, the walls of which are lined with large and well-formed feldspar crystals. It is the coarse crystallization of the marginal feldspar of such cavities, as well as of the associated minerals, that imparts pegmatitic character to the dykes, the main portions of which are often little coarser-grained than ordinary syenite. It is from the cavities that most of the minerals here described have been obtained.

Characteristic of the dykes is the mineral filling of their cavities, this consisting principally of (a) calcite (Faraday and concession 10 of Cardiff), and (b) fluorite and calcite (concession 21 of Cardiff).

In Faraday, groups of lepidomelane crystals, some of them of enormous size, occur upon the feldspar of the walls, sometimes associated with tourmaline and fluorite, while apatite and smaller lepidomelane crystals occur embedded in the calcite.

On concession 21 of Cardiff, fluorite is by far the most abundant miarolitic mineral, with calcite in lesser amount scattered through it. On lot 5, large apatite and hornblende crystals lie embedded in the fluorite, in which also occur magnetite and uraninite crystals of considerable size. The cavity here is of exceptional extent, being at least 150 feet long by 5 to 10 feet wide and partaking of the nature of a vein. This vein is being developed at the present time for uraninite, which occurs in considerable amount. The occurrence has lately been described by the writer (24). In some of its main features, it seems to resemble the uraninite-bearing deposit at Wölsendorf, in Bavaria (39).

ALBITE

The predominating feldspar of the pegmatites, according to Adams and Barlow (36, pp. 229-240), is plagioclase, ranging from albite to andesine. The only feldspar considered in this paper is that which occurs in well-formed crystals lining the walls of miarolitic cavities. In Faraday, this is flesh-coloured, exhibits the twinning striations characteristic of plagioclase, and on the basis of a microscopic examination by Walker and Parsons (38), albite. In Cardiff, the feldspar is predominantly orthoclase.

The very perfect feldspar crystals lining the walls of cavities in these dykes are one of the interesting features of the pegmatites, since feldspar crystals are rare in the granite pegmatites. The Faraday crystals attain a length of about 4 inches, while those from Cardiff are sometimes as much as 6 inches long. The Faraday crystals exhibit interesting corrosion pitting, possibly by the agency of fluorine vapours, since fluorite occurs filling in the spaces between crystals. The corrosion seems to have proceeded along cleavage planes, and the resulting regular pitting figures resemble in form the quartz pattern in graphic granite. Corrosion has been selective, certain faces being more deeply pitted than others.

ALLANITE

Miller mentions (40) the occurrence of allanite in the massive pegmatite of the Richardson mine, in Cardiff, as does also Ellsworth (23). The mineral has not been observed by the writer.

APATITE

Apatite is an important constituent of the dykes, and occurs as well-formed crystals, ranging up to 30 pounds in weight, embedded in calcite (Faraday) or fluorite-calcite (Cardiff). The colour varies from yellow to green or red. The mineral is clear and glassy and very brittle. Clear fragments of considerable size and without visible flaws can often be picked from broken crystals. On crystals exhibiting terminal faces, there is often a conspicuous development of the basal plane. This is sometimes so pronounced that the crystals appear to have almost square ends. In this respect, the apatite of these dykes differs from that of the basic (pyroxenite) pegmatites, the crystals of which seldom, if ever, exhibit the basal plane. The apatite occurs always in free crystals, no massive, compact material being observed. Small, nodular masses of fluorite are often enclosed within the Cardiff apatite. The Faraday apatite has been described by Walker and Parsons (38).

Ellsworth has detected (23) small amounts of cerium and other rare earths in the brown apatite from the Richardson mine, in Cardiff.

AUTUNITE

Occurs sparingly as minute plates, associated with torbernite upon apatite, at the Richardson mine, in Cardiff township.

CALCITE

Calcite seems to be almost universally present in the dykes, usually as one of the principal cavity-filling minerals. In Faraday, a large mass of rather coarsely-crystalline, cream-coloured calcite constitutes the filling of a large cavity, and carries scattered through it well-formed apatite and lepidomelane crystals. On concession 21 of Cardiff, calcite is subordinate to fluorite, and occurs in small grains scattered throughout fluorite: the two minerals sometimes exhibit a banded arrangement. At the surface, the calcite has often been leached out, resulting in open pockets in which lie free crystals of apatite, tourmaline, uraninite, etc.

On concession 10 of Cardiff, where a number of small openings have been made, the calcite ranges in colour from light, creamy-pink to dark, reddish-brown: it is predominantly fine-grained. Small apatite and lepidomelane crystals, as well as crystallized ellsworthite, occur scattered through it. In the vicinity of the last-named, the calcite always is of a characteristic, purplish shade.

Ellsworth has discussed (23) the occurrence of calcite in the syenite and granite pegmatites.

CHALCOPYRITE

Occurs in small amount in the massive pegmatite of the Richardson mine, in Cardiff (23).

DIOPSIDE

Rarer than hornblende, but present in medium-sized, free crystals in the fluorite workings on lots 8 and 9 in concession 21 of Cardiff township.

ELLSWORTHITE

Ellsworth has described (37) crystallized ellsworthite from lot 10 in the 12th concession of Cardiff township. The crystals are of rounded octahedral habit and range from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. They occur embedded in calcite, associated with small apatite crystals. The original ellsworthite from Hybla, Ont., has not been found there in crystal form.

EUXENITE

Small pellets and veinlets of euxenite occur associated with lepidomelane in Faraday.

FLUORITE

Fluorite, of a deep purple colour, is extremely abundant in the pegmatite in the 21st concession of Cardiff township, where it forms the principal mineral filling of miarolitic cavities. Attempts to mine the Cardiff fluorite have been made, but it proved to contain too much calcite, apatite and other accessory minerals to be of commercial grade without concentrating. Finely disseminated fluorite occurs also as an accessory mineral in the massive pegmatite bordering the fluorite workings on lots 8 and 9 in this concession. In Faraday, it is much less common, occurring only in small amount as granular material between feldspar and lepidomelane crystals lining the walls of cavities. Interesting, small masses of finely-granular, colourless fluorite were observed here, which exhibit on their surfaces spherulitic patches of a purple shade. These patches are sometimes as much as $\frac{3}{4}$ inch in diameter. The material had been exposed to weathering, which usually exercises a rather rapid bleaching effect on the fresh fluorite of the dykes. It would appear that the purple patches of the material in question owe the retention of their colour to a central nucleus of a radium-bearing mineral, the emanations of which have proved sufficient to negative, or at least to materially slow down, the bleaching effect of sunlight.

The Cardiff fluorite varies from coarsely-to finely-granular. It has not been observed in free crystals. The coarser material usually contains considerable pale, pinkish-buff, coarsely-granular calcite mixed through it, or in banded arrangement with it. The finer-grained, on the other hand, contains comparatively little visible calcite. The fluorite is deep purple-violet, almost black, in colour when fresh, but fades to a pale violet shade on exposure to sunlight; the finer-grained material fading much more rapidly than the coarse. The former also weathers readily to a loosely-coherent, powdery material, whereas the coarser remains unaffected.

The other miarolitic minerals appear to occur, for the most part, distributed in irregular fashion through the cavity-filling material. In Faraday, however, the bulk of the lepidomelane is found along the cavity walls, with a subordinate amount in the form of large crystals disseminated through the calcite.

The deep purple colour of the fluorite, which at the Richardson mine, in Cardiff, is noticeably darkest around the crystals and masses of uraninite, is evidently due to the effect of radioactive emanations from radium-bearing solutions and from the uraninite. Such dark purple fluorite is a common associate of uraninite in other parts of the world, *e.g.* Jachymov, Freiberg, etc.

In Cardiff, the fluorite surrounding uraninite is usually fine-grained. A noteworthy feature of such fine-grained, almost black, fluorite is that when freshly-broken or struck with the hammer, it liberates a strong odour resembling that of ozone (24). This odour is of practical service in the mining of the uraninite, since it indicates to the workmen that they are breaking into a pocket of uraninite. Sine has investigated (4) the gas liberated by a similar fluorite from the granite pegmatite at the McDonald mine, near Hybla, some 25 miles distant, and has determined it as free fluorine. He found that 10 volumes of the Hybla fluorite contained about 8 volumes of fluorine. Similar strongly-foetid, purple fluorite was described (*Dana, 6th Ed.*, p. 163) many years ago from Wölsendorf, in Bavaria, under the name antozonite.

GUMMITE

Thin crusts of lemon-yellow to vivid orange-scarlet uranium salts often coat or penetrate massive uraninite at the Richardson mine, in Cardiff township. Under the microscope, most of such material exhibits a waxy, amorphous structure and is probably gummite. Occasionally, there is an approach to obscure crystal structure.

HORNBLENDE

Large, stout crystals of black hornblende are common as scattered individuals embedded in the calcite, or calcite-fluorite, filling of cavities. In Faraday, the crystals attain a length of 2 feet, and in Cardiff, individuals almost as large occur.

LEPIDOMELANE

The lepidomelane variety of biotite occurs in Faraday in large amount and often in crystals of enormous size (18, No. 701). Plates have been secured measuring over 4 feet in diameter. The mineral is less common in the Cardiff dykes, but occurs in some amount in the massive pegmatite at the Richardson mine.

The Faraday lepidomelane has been described by Walker and Parsons (38). It is deep black in colour, and greenish-brown in thin films by transmitted light. The crystals possess good crystal form, but are frequently considerably pitted and corroded, possibly by fluorine vapours. The mineral contains over 2 per cent of fluorine, and fluorite is often present in the interstices between the crystals. Apatite crystals and small nodular masses of calcite are often enclosed within the crystals. The lepidomelane individuals from this occurrence are probably the largest on record.

Interesting specimens were obtained by the writer at this locality, showing feldspar undergoing alteration to mica. Incipient development of mica plates within the feldspar, and extending from a partly-formed mica crystal, is plainly shown. Similar examples of muscovite replacing feldspar have also been observed in a granite pegmatite in East Portland township, Que., where what appeared at first sight to be well-formed muscovite crystals, 2 to 3 inches in diameter, were found to be composed of a dull, "stony" material, possessing only traces of mica cleavage.

MAGNETITE

Magnetite is abundant at the Richardson mine, in Cardiff, where it occurs in large crystals, sometimes several inches in diameter and exhibiting very perfect octahedral cleavage, and also in irregular masses, embedded in miarolitic calcite-fluorite. The massive material is frequently intergrown with uraninite, apatite or hornblende. Masses up to 200 pounds in weight are stated to have been found (23).

In Faraday, magnetite occurs more sparingly, as small isolated masses. Some of it has been altered to martite.

The Cardiff magnetite is stated by Ellsworth (23) to be titaniferous.

MOLYBDENITE

Small amounts of flake molybdenite are stated to have been found in massive pegmatite at the Richardson mine, in Cardiff. As in the normal granite pegmatites, the mineral is rare.

MUSCOVITE

Muscovite mica is comparatively rare in the pegmatites and was not observed in Faraday or Cardiff. Adams and Barlow mention (36) the occurrence of large crystals in a dyke on the first concession of Monteagle township, near Bancroft.

NEPHELITE

Nephelite occurs in small grains as a minor, rock-forming constituent of the massive pegmatite in Cardiff, and probably elsewhere in the district.

PYRITE

Pyrite occurs in small amount scattered through the miarolitic calcite and fluorite of Faraday and Cardiff. Crystals have not been observed, the material being in the form of small grains or shapeless masses. The concentrates made in the Mines Branch laboratories from a shipment of uraninite ore from the Richardson mine, in Cardiff township, proved to contain an appreciable amount of fine pyrite, although the ore itself showed but little macroscopic sulphide.

PYRRHOTITE

Occurs in very small amount in the Faraday dyke, and also in Cardiff (23).

TITANITE

Mentioned by Miller (40) and Ellsworth (23) as occurring in the massive pegmatite at the Richardson mine, in Cardiff. Microscopic titanite has been noted by the writer as an accessory constituent of the massive pegmatite bordering the fluorite workings on lots 8 and 9 in the same concession of Cardiff. The mineral also occurs in minor amount in the Faraday dyke.

TORBERNITE

Small plates of torbernite, seldom over 1 mm. in diameter, have been observed coating apatite in the main pit of the Richardson uraninite mine, in Cardiff township. In view of the large amount of apatite that accompanies the uraninite, and of the considerable degree of surface leaching that has taken place, secondary uranium phosphates are surprisingly scarce here.

TOURMALINE

Ellsworth mentions (23) the occurrence of tourmaline in the massive pegmatite at the Richardson mine, in Cardiff township. It occurs in some quantity in the Faraday dyke, where stout, short, mis-shapen crystals, up to 2 inches in diameter, were found loose in a leached fissure-vug between the calcite-filling and wall of a miarolitic cavity. The tourmaline lay among the lepidomelane and feldspar crystals lining the wall of the cavity, and had evidently been deposited with these minerals. Like the mica and feldspar, it is severely corroded, and has apparently been attacked by fluorine vapours.

URANINITE

The pegmatite dyke at the Richardson mine, in Cardiff township, is remarkable for the amount of uraninite that it carries. Small occurrences of uraninite had been found at scattered outcrops on the property previous to 1929, and were described by Miller (40). These discoveries seem to have been made mostly in massive pegmatite, in which the uraninite is stated to have occurred associated with black mica, and often enclosed in mica "books." In 1929, however, a miarolitic cavity of unusual size was uncovered, which has proved to contain a considerable amount of uraninite in scattered crystals and irregular masses, embedded in a fluorite-calcite matrix.

The cavity in question possesses a proved length of 150 feet and is probably much longer, since outcrops occur for a fur her 350 feet along the strike; these, however, may be isolated, separate cavities and not part of the main pocket. The width of the main cavity ranges from 5 to 8 feet, while at one of the outcrops, the width between walls is 12 feet. The deposit thus approximates in character to a vein. It has a dip of about 45°. The occurrence has already been described by the writer, and its economic possibilities described, in a recent paper (24).

The uraninite, which, as far as yet known, is the only radioactive mineral (outside of its minor alteration products) present in the deposit, occurs as well-formed crystals, or groups of crystals, and nodular lumps, embedded in the fluorite-calcite filling of the cavity. The crystals range from small forms $\frac{3}{8}$ inch in diameter to individuals measuring nearly 2 inches across (Fig. 3). They are of predominantly cubic habit, usually more or less modified by the octahedron. The faces are often somewhat pitted and indented, and perfect crystals are rare. The lumps range from small pea-like bodies to masses weighing several pounds.

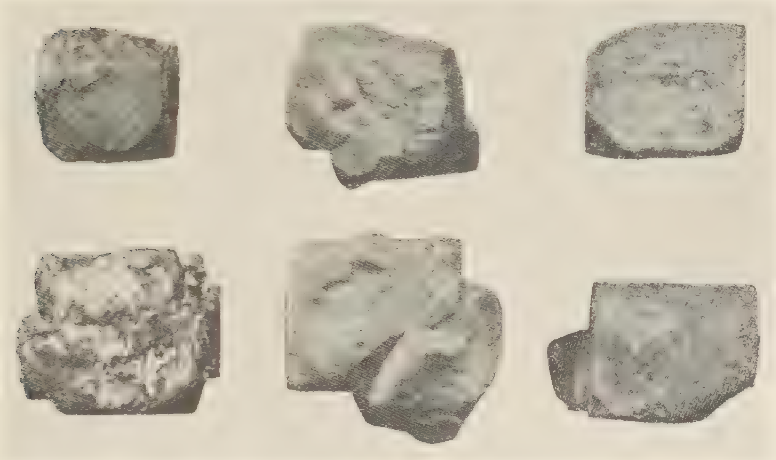

FIG. 3. Uraninite crystals from lot 5, concession 21, township of Cardiff, Ont. ($\frac{1}{2}$ Natural size).

Externally, the uraninite is usually rather severely altered to a soft, greenish-black substance (U_3O_8?). This alteration often penetrates to a considerable depth, and in some cases, the entire lump or crystal has suffered change. Nodules embedded in matrix are frequently seen to be surrounded by a thin film of red hematite. It should be noted that these observations on alteration have all been made on uraninite taken from within a short distance (20 feet) of the surface, no other material being yet available.

Under the microscope, the uraninite is frequently seen to enclose small grains, and sometimes also veinlets, of calcite, fluorite and pyrite.

Ellsworth has analyzed and described (23) this Cardiff uraninite, and it has also been described by Walker (22). The analyses show 61.64 and 69.71 per cent U_3O_8, respectively. The age of the pegmatite on the basis of Ellsworth's analysis, is 1,299 millions of years, while Walker has calculated it as 1,239 millions.

Uraninite has not been observed by the writer in any of the other dykes of the district, but Miller mentions (40) the occurrence of uranium minerals in a dyke in Monmouth township, about 9 miles southwest of the Richardson mine.

Uranothallite (?)

Thin incrustations of a yellowish-green mineral that has not yet been identified, but which may be uranothallite (hydrous uranium-calcium carbonate), occur coating uraninite crystals at the Richardson mine, in Cardiff.

Zircon

In contrast to the granite pegmatites, which often carry considerable amounts of the cyrtolite variety of zircon, the syenite pegmatites appear to contain only the fresh, unaltered form.

Zircon appears to be a common accessory constituent of the nepheline syenites of the region, as observed by Adams and Barlow (36, p. 252). It occurs in some quantity in the medium-grained pegmatite dyke-mass at the Richardson mine, in Cardiff township, in scattered, small, brown, prismatic crystals seldom measuring over $\frac{3}{8}$ by $\frac{1}{8}$ inches. It appears to possess a rather zonal distribution in the dyke, being abundant in some parts of it while not visibly present in others. It has not been observed as a cavity mineral.

APPENDIX

Comparatively little in the way of detailed mineralogic studies on the minerals that occur in other types of Canadian pegmatites has yet appeared in the literature. However, it may be of interest to enumerate briefly here, incomplete as the lists may be in some cases, the minerals that have been observed in certain types of pegmatites having a restricted regional development in various parts of Canada. The pegmatites here considered are:

(1) Tin-bearing pegmatites of New Ross, Nova Scotia.
(2) Mica-apatite pyroxenite pegmatites of Ontario and Quebec.
(3) Lithium pegmatites of southeastern Manitoba.
(4) Granite pegmatites of British Columbia.

(1) The Tin-Bearing Pegmatites of New Ross, Nova Scotia

The occurrences and the minerals of these dykes have been described by Faribault (41), and, more recently, by Walker and Parsons (22). The minerals are described as occurring in pegmatitic segregations in grey granite, the association resembling that at Branchville, Connecticut. The species identified comprise the following:

Albite
Amblygonite
Apatite
Arsenopyrite
Beryl
Bismuthinite
Cassiterite
Chalcopyrite
Columbite
Durangite
Fluorite
Galena
Haematite
Hübnerite
Kaolin
Lepidolite
Limonite
Magnetite
Manganapatite
Manganite
Monazite
Molybdenite
Pyrite
Pyrolusite
Quartz
Scheelite
Siderite
Sphalerite
Topaz
Tourmaline
Wolframite
Zinnwaldite

(2) The Pyroxenite Pegmatites of Ontario and Quebec

These pegmatites, which have been extensively mined for the amber mica and phosphate that they carry, have a considerable development in the Ottawa region. They have been fully described in two reports of the Mines Branch (18), the earlier of which (No. 118) describes their minerals in some detail and contains a bibliography. Comparatively few of these associated minerals, however, have been the subject of mineralogic study. Large diopside crystals from Hull township, Que., have been described by Walker and Parsons (21), and zircon from North Burgess township, Ont., by Palache and Ellsworth (42).

Probably the most noteworthy minerals yielded by dykes of this type are the enormous crystals of zircon and titanite that were found many years ago in the townships of Sebastopol and Brudenell, Ont. (23).

The list of recorded species from the dykes comprises the following:

- Actinolite
- Albite
- Allanite
- Anhydrite
- Anthraxolite
- Barite
- Celestite
- Cenosite (62)
- Chabazite
- Chalcopyrite
- Chlorite
- Datolite
- Epidote
- Faujasite
- Fluorite
- Galena
- Garnet
- Goethite
- Graphite
- Hematite
- Hornblende
- Magnetite
- Microcline
- Molybdenite
- Natrolite
- Olivine
- Orthoclase
- Prehnite
- Pyrite
- Pyrrhotite
- Quartz
- Rennselaerite
- Rutile
- Scapolite
- Serpentine
- Specularite
- Sphalerite
- Spinel
- Steatite
- Titanite
- Tourmaline
- Tremolite
- Vesuvianite
- Wilsonite
- Zircon

(3) The Tin and Lithium Pegmatites of Southeastern Manitoba

The discovery of these pegmatites was made in 1924, and there has since been a small amount of mining development done upon them, chiefly for lithium minerals (18, No. 701) (43), and also for tin and beryl (61).

The occurrences resemble somewhat the lithium pegmatites of the Black Hills, in South Dakota. The following partial list of recorded minerals is a short one, but doubtless it will be considerably extended as further development of the deposits proceeds. It may be noted that the presence of germanium has been detected by Papish (44) in the topaz from the Silver Leaf mine (Fig. 4), and of rubidium and gallium in the deep purple lepidolite and brown zinnwaldite (?) from the same property.

Albite (cleavelandite)
Arsenopyrite
Beryl
Cassiterite
Columbite
Cookeite
Epidote
Fluorite
Ilmenite
Lepidolite
Lithiophilite
Magnetite
Montebrasite
Muscovite
Pollucite (trace)
Quartz
Sphalerite
Spodumene
Tantalite
Topaz
Tourmaline
Zinnwaldite (?)

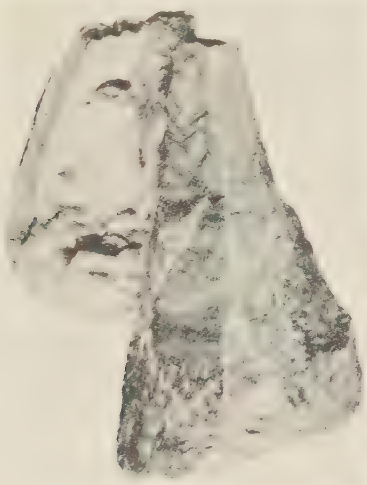

FIG. 4. Large, tapering crystal of topaz, with adhering massive topaz, from Silver Leaf mine, Winnipeg river, Manitoba. ($\frac{1}{2}$ Natural size).

(4) GRANITE PEGMATITES OF BRITISH COLUMBIA

The granite pegmatites here considered comprise a series of dykes that occur throughout a narrow belt extending from the Big Bend of the Columbia river to Fort Grahame, on the Finlay river, a distance of 400 miles. These dykes carry muscovite mica, for which a small amount of desultory mining has been conducted during the past 30 years. Their mineral association has not been studied in any detail, but the following species have been reported (18, No 701) (45), (46), (47):

Albite
Apatite
Beryl
Biotite
Cyanite
Garnet
Hornblende
Microcline
Muscovite
Pyrite
Quartz
Tourmaline

Of these minerals, possibly the most interesting is cyanite, a mineral that is not usually found in pegmatites. It occurs in some quantity in large, bladed crystals of typical cyanite form, and of a fine blue shade, in the pegmatites of the Tête Jaune district.

AUTHOR'S NOTE

The list of minerals recorded from pegmatites in various parts of the world is so large, and comprises so many interesting species—many of them known to occur, in mineralogically interesting form, at least, only in such rocks—that it is a matter of some surprise that no comprehensive work devoted solely to the pegmatites and their minerals has yet appeared. Many interesting papers dealing either systematically or individually with the pegmatite minerals of certain regions have been written, but these are so scattered through the literature as to be difficult of access. The compilation of a "Mineralogy of the Pegmatites," which would constitute a digest of such scattered information, should result in a volume that would fill a pronounced gap in our mineralogical literature. To the preparation of such a work, authorities in many countries would almost certainly be willing to contribute, by furnishing additional data, reference synopses, etc. It is, perhaps, not too much to hope that we shall, in the near future, see a treatise such as indicated, and that this will include a critical examination, in the light of world evidence, of the interesting replacement theory put forward for the pegmatites (of the United States) by Schaller (1b), and discussed by Hess (1a) and Landes (50).

In as far as the writer's own observations on the granite pegmatites of eastern Canada are concerned, soda-rich feldspar usually, though perhaps not invariably, surrounds such minerals as biotite, muscovite, tourmaline and beryl, and is particularly in evidence around the rare element minerals, allanite, cyrtolite, titanite, monazite, etc. Albitization of original microcline in such situation may, therefore, be presumed to have taken place.

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NOTES AND NEWS

MINERALS AT MANTON, RHODE ISLAND*

Duncan Stewart, Jr., *Detroit, Michigan.*

Introduction. There is a small glaciated area in the vicinity of the town of Manton, Rhode Island, three miles to the west of the City of Providence, that is, geologically speaking, of a very complex nature. At Manton a quarry is located the rock of which is used for road material. Inasmuch as quarrying operations have produced a pit the geological and mineralogical problems can therefore be studied in considerable detail.

The general area is one of greatly metamorphosed igneous and sedimentary rocks. A pre-Cambrian quartzite is intruded by fine-textured greenstones, also of pre-Cambrian age. The greenstones are considered to be metamorphosed dikes and sills of either basalt or some other basic rock of similar nature. Intruded into the quartzite and the greenstones are dikes and stocks of granite of probably Devonian age. There are lenticular masses of marble and steatite in the greenstones. In the vicinity are also to be noted veins of quartz, quartz-tourmaline, quartz-epidote, calcite-epidote, talc-calcite, chlorite-calcite, and chlorite.

Minerals Recorded Previously in the Area. In 1926 Messrs. L. W. Fisher and E. K. Gedney[1] listed the following twenty-eight minerals from Manton: actinolite, ankerite, apatite, asbestos, boltonite, calcite, chalcopyrite, chlorite, clinochlore, dolomite, enstatite, epidote, hematite, hornblende, limonite, magnetite, malachite, orthoclase, pyrite, pyroxene, pyrrhotite, quartz, rhodochrosite, rhodonite, serpentine, steatite, talc, and tremolite.

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* A part of the thesis submitted in partial fulfillment for the degree of Master of Science in Brown University, June 1930.

[1] L. W. Fisher and E. K. Gedney, Notes on the Mineral Localities of Rhode Island. 1. Providence County: *American Mineralogist*, **11**, 1926, pp. 339, 340.

Three of the above minerals were not found by the writer, namely: boltonite, rhodochrosite, and rhodonite. This can be accounted for by the fact that quarrying operations have been carried on in the vicinity and the exposures containing these minerals have been removed. With the continuance of the operations minerals new to the area have been uncovered.

DESCRIPTIONS OF RECENT ADDITIONS TO THE LIST OF MINERALS. Eleven additional minerals may be added to the above list, namely:

MINERAL	OCCURRENCE
Antigorite.	Main constituent of the serpentine rocks.
Biotite.	Common constituent of practically all of the greenstones. Also, in granite.
Fluorite.	A very rare constituent occurring as minute octahedra in the steatite.
Ilmenite.	As tabular crystals in the talcose surface of the serpentine. Microscopically it is seen to be a common constituent of the greenstones, and is closely associated with the titanite. Also, found as minute needles in some sections of the quartzite.
Pargasite.	Typical mineral in contact zones of granite and greenstones.
Plagioclase.	Sparingly in thin sections of greenstones.
Rutile.	Sparingly as striated prismatic crystals with calcite.
Titanite.	Golden yellow to light brown twinned crystals in veins and lenses of chlorite, and sparingly in chlorite-calcite veins in the greenstones. (See discussion of titanite.)
Tourmaline.	Uncommon. In stringer-like black tourmaline-quartz veins in the quartzite.
Zircon.	Microscopically in the quartzite.
Zoisite.	In contact zones of granite with greenstones. Associated with actinolite, clinochlore, and pargasite.

As stated above, the titanite at Manton is found in veins and lenses of chlorite in the greenstones, and sparingly in chlorite-calcite veins. The titanite crystals are golden yellow to light brown in color; large, and commonly twinned. Fish tail twins are numerous. An average specific gravity of the Manton titanite is 3.666, which is slightly higher than that of the normal titanite, 3.54, as recorded by F. W. Clarke.[2] Inasmuch as the element titanium is isomorphous with the elements zirconium, cerium, yttrium, and thorium, it is suggested that the greater specific gravity of the Manton titanite may be due to the replacement of some of the titanium molecules by one or more of the above elements. A chemical analysis for these elements is to be made.

The country rock, the greenstones, contain the elements that make up the constituents of the veins and lenses which contain the titanite crystals. This naturally leads to the assumption that the rocks in which the crevices have been formed have themselves furnished the material for the filling. Mr. I. Campbell[3] in his article on Alpine mineral deposits noted a distinct similarity between the chemical composition of several rocks of the Alps and certain "vein" fillings.

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[2] F. W. Clarke, The Data of Geochemistry: *U.S.G.S. Bul.*, **770,** 1924, p. 353.

[3] I. Campbell, Alpine Mineral Deposits: *American Mineralogist*, **12,** 1927, p. 161.

SUMMARY. At Manton, Rhode Island, are to be found greatly metamorphosed igneous and sedimentary rocks. Quartzite is intruded by metamorphosed basic greenstones, and granite intrudes both the quartzite and the greenstones. Lenticular masses of marble and steatite are found in the greenstones. A total of 39 minerals have been identified up to the present time. Of these, 11 minerals may be added to the list compiled in 1926. An interesting occurrence of titanite is mentioned. The titanite crystals occur in veins and lenses of chlorite in the greenstones, and sparingly in chlorite-calcite veins.

BOOK REVIEW

HANDBOOK OF CHEMICAL MICROSCOPY. ÉMILE MONNIN CHAMOT AND CLYDE WALTER MASON. Volume I. Principles and Use of Microscopes and Accessories; Physical Methods for the Study of Chemical Problems. XIII+474 pages with 162 figures. John Wiley and Sons, New York. **1930**. Price $4.50 net.

Although this edition is based on Chamot's "*Elementary Chemical Microscopy*" it may properly be considered a new book because of the large amount of new material that has been added and the broader scope of the work. It should be of considerable interest to mineralogists and petrographers because of the emphasis placed on petrographic methods as an important aid to the chemist.

In Chapter IX the authors have devoted 64 pages to the theories underlying the use of the petrographic microscope. The treatment of optical theories in this chapter is somewhat novel because of the simplified presentation of the subject matter. This attempt to avoid the rigorous and formal development of optical principles so common to textbooks on petrography may develop a few misconceptions, for example, the production of polarized light by the nicol prism (page 269). If a few photographs of interference figures, or even drawings, had been included in this chapter it would have added considerable clarity to the text especially for those not very familiar with optical methods.

In Chapter XI "Determination of Refractive Indices of Liquids and Solids" the authors recommend that α and γ be determined upon the particles showing lowest and highest indices of refraction. While for most crystals this method will give representative values, it is always best to check the orientation of these particles, whenever it is possible to do so, by obtaining interference figures from them.

The microscopist in any field will find in this book a handy reference work which discusses the microscope and its accessories in a semi-technical and readily understandable fashion. The petrographer, who is called upon to teach optical methods to chemists, will be especially interested in the list of easily crystallized chemical substances (showing characteristic orientations) tabulated on pages 311–315.

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